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Vladimir K. Zworykin

THE EARLY DAYS: SOME RECOLLECTIONS

I OWE my own lifelong interest in television to Dr. Boris Rosing, my physics professor at the St. Petersburg Institute of Technology. I was privileged to assist Dr. Rosing many an evening in his private laboratory, setting up a great variety of experiments on apparatus for the generation of television signals and for electrical picture reproduction.

Rosing employed rotating mirrors and a photocell in his transmission equipment, much as did several of his predecessors. On the other hand, he sought to accomplish picture reproduction with the aid of a primitive Braun tube or cathode-ray tube, a technique which had been employed up to then—unknown to him—only by his contemporary, Dieckmann. Furthermore, Rosing was firmly convinced not only that television was coming but that, when it came, it would be electronic television. And he managed to pass on this conviction to me, his student and assistant.

My association with Rosing was terminated upon my graduation in 1912, when I accepted a scholarship to engage in x-ray research under the well-known French physicist Paul Langevin. But World War I deferred for many years any possibility of pursuing my interest in television. In fact, even after I had come to the United States in 1919 and had joined the laboratory staff of the Westinghouse Electric and Manufacturing Company in Pittsburgh the following year, I found it difficult to persuade my superiors to let me work in a field of such questionable prospects. Only upon returning to Westinghouse after an interim with a mid-western oil development company was I given a sufficiently free hand to test some of the television ideas which had been maturing within me.

The most immediate problem appeared at the time to be the invention of an electronic generator of television signals, since the work of Rosing and Dieckmann had already established the feasibility of reproducing television images with the cathode-ray tube. Such an electronic picture generator, or "camera tube," could be endowed, as I saw it, with two important advantages: first, it did away with the need of high-speed mechanical scanning devices; and, second, it permitted the use of signal storage—i.e., the utilization for the picture signal of charge accumulated photoelectrically by a picture element throughout a picture period.

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An electronic picture signal generator had indeed been proposed by A. A. Campbell-Swinton in a lecture before the Roentgen Society in London as early as 1911; this, however, did not come to my attention until after its publication in the *Wireless World and Radio Review* in April, 1924. Campbell-Swinton's picture signal generator, while incorporating a number of features essential to any practical camera tube, possessed several other aspects which made its practical realization impossible. Necessarily, my approach to the problem had to be quite different.

The very first tube which permitted me to demonstrate the principle of all-electronic television is still in existence. Its most important component is a very thin aluminum oxide film supported by a thin aluminum film on one side and a photosensitive (potassium hydride) coating with high transverse resistance on the other. The picture was projected through a fine-wire collector grid, in front of the aluminum oxide film, onto the photosensitized side of the film, while a high-velocity electron beam scanned the opposite side. Illuminated portions of the photosensitive "mosaic" which charged up negatively by photoemission to the collector between successive scans were momentarily shorted to the aluminum coating or signal plate by the scanning beam penetrating to the insulating substrate. This resulted in a signal pulse proportional to the illumination of the scanned element in the signal plate and collector circuits. The process as described depended on bombardment-induced conductivity, a phenomenon investigated at a much later date by Pensak.

With this "camera tube" and a cathode-ray tube as picture reproducer, the essential terminal elements of an electronic television chain had become available to me. Further more, De Forest's invention of the audion, or vacuum tube amplifier, enabled me to amplify the weak signal currents provided by the camera tube to a level at which they could modulate effectively the beam current in the cathode-ray tube employed as picture reproducer. Thus I could not only describe the operation of my all-electronic television system, but could also demonstrate it.

By present standards the demonstration, which was made to a group of Westinghouse executives toward the end of 1923, was scarcely impressive. The transmitted pattern was a cross projected on the target of the camera tube; a similar cross appeared, with low contrast and rather poor definition, on the screen of the cathode-ray tube. The performance indicated not only the fundamental soundness of the system but also the tremendous improvement in the components which had to be realized to create a useful television system. In particular, the preparation of satisfactory thin-film targets for the camera tube exceeded the capabilities of the technology of that day. The first practical television storage camera tubes, built

some seven or eight years later, departed, in fact, from the original design by employing targets which were scanned on the side upon which the picture was projected. These tubes with a relatively thick "one-sided" target I named "Iconoscopes."

However, I am getting ahead of my story. Apart from general studies of modifications and extensions of the television system, my attention was first directed toward the problem of improving the cathode-ray tube as a viewing device.

In the tubes employed in the early demonstrations, the electron beam was defined simply by apertures and relied on gas focusing—i.e., the attraction of the beam electrons by positive ions formed by impact on inert gas atoms—to hold it together. This technique, however, imposed severe limitations on the sharpness and brightness of the scanning spot employed to trace the image on the viewing screen.

Accordingly, I set about focusing the electron beam in a highly evacuated, "hard," tube by means of electrostatic field between apertured diaphragms and cylinders at suitably chosen potentials, centered on the axis of symmetry of the tube. The general feasibility of this approach was suggested by the proof brought by Hans Busch in 1927 that axially symmetric electric and magnetic fields acted on electron beams in the same manner as glass lenses acted on light beams.

By 1929 I could demonstrate, at the Eastern Great Lakes District Convention of the Institute of Radio Engineers (November 18, 1929), a television receiver employing a viewing tube with the essential properties of a modern television viewing tube: a hard vacuum, an indirectly heated oxide cathode, an apertured grid as beam current modulator, and a first and second anode with their voltage ratio adjusted so as to form a sharp image spot on the fluorescent screen of a minimum beam cross section, or crossover, near the cathode. I called this tube a "Kinescope." The television signals employed for the demonstration were obtained by the mechanical scanning of motion picture film by means of an oscillating mirror.

Shortly before this time an event occurred which vitally affected the further development of my work in television. This was a meeting with David Sarnoff, then Vice-President and General Manager of the Radio Corporation of America, in which I had an opportunity to explain my ideas and hopes for electronic television. Sarnoff quickly grasped the potentialities of my proposals and gave me every encouragement from then on to realize my ideas.

In the course of a reorganization in 1929 of the activities of the General Electric Company, Westinghouse, and RCA, I was transferred to the RCA Victor Company in Camden, New Jersey and was made Director of the Electronic Research Laboratory. This enabled

me to concentrate entirely on research on basic electronic processes and devices essential to electronic picture signal generation and picture reproduction. Assisting me was an adequate staff of engineers and scientists. In addition, I enjoyed the close cooperation of other research teams in Camden, Harrison, and New York which specialized in investigations of television system principles, circuitry, high-frequency tube design, signal propagation, and studio technique.

Progress now was rapid. By 1931 Iconoscopes had been built which demonstrated clearly the advantages of the electronic camera tube with storage over the earlier mechanical television pickup techniques. Within a few years all-electronic television replaced earlier mechanical efforts. Although tremendous efforts of a technological and organizational nature were still needed to establish television as an essential part of our culture, the main roadblocks to further progress had been removed.

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Robert H. Stern

TELEVISION IN THE THIRTIES

THE STATUS OF television during the mid-Nineteen Thirties was in marked contrast to its condition at the beginning of that decade. Earlier the impulse to exploit it commercially had overmatched its technical capabilities; now the pressure to commercialize was temporarily lessened.[1] By this time the development of electronic methods for the scanning and reproduction of the televised image had reached a level of performance capability superior to that of any of the mechanical scanning systems upon which much of the earlier developmental and promotional effort had been spent. The future of the art technically, it was now clear, would follow the course along which Philo Farnsworth and Vladimir Zworykin had been moving in their separate experimentations since the previous decade. The work of these men on the design of basic instruments and techniques had provided the essential elements of electronic television; now steady progress was being made in the improvement of such instruments and techniques looking to their practical application.

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